Claims

What is claimed is:

1. A method for generating multiple level transmit waveforms, the method comprising:

(a) ~~generating~~ applying a first voltage level in response to a first switch;

(b) ~~generating~~ applying a second voltage level in response to a second switch; and

(c) outputting a transmit waveform having at least three different non-zero peak amplitudes from a first transformer in response to (a) and (b) as a function of time.

2. The method of Claim 1 wherein (a) comprises ~~generating~~ applying the first voltage ~~with~~ on the first transformer, (b) comprises ~~generating~~ applying the second voltage ~~with~~ on a second transformer in series with the first transformer.

3. The method of Claim 1 wherein (a) and (b) comprise generating the first and second voltages on first and second separate flux paths of the first transformer and (c) comprises outputting the transmit waveform from a secondary winding around a third flux path of the first transformer, the third flux path separate from the first and second flux paths.

4. The method of Claim 1 wherein (a) and (b) comprise applying first and second voltages on first and second flux paths, respectively, of the first transformer; and (c) comprises generating a third voltage on a third flux path as a function of the first and second voltages.

5. The method of Claim 4 wherein (c) comprises superposing magnetic flux from the first and second flux paths in the third flux path.

6. The method of Claim 4 wherein the first and second voltages are ternary (+, - and 0).

7. The method of Claim 4 further comprising:

(d) applying a fourth voltage on a fourth flux path of the transformer;

wherein (c) comprises generating the third voltage as a sum of the first, second and fourth voltages.

8. The method of Claim 4 further comprising:

(d) tapping a first primary winding around the first flux path to a first voltage source; and

(e) closing one of first and second switches connected to opposite ends of the first primary winding.

9. The method of Claim 4 further comprising:

(d) connecting an untapped winding around the first flux path to ground when the first voltage is zero.

10. The method of Claim 4 further comprising:

DP 2/15/02 JAP 2/5/02 (d) ~~supplying~~ applying the first voltage in response to a first voltage source tapped to a first primary winding on the first flux path;

DP 2/15/02 JAP 2/5/02 (e) ~~supplying~~ applying the second voltage in response to a second voltage source tapped to a second primary winding on the second flux path;

wherein the first and second voltage sources are operable to output different voltages.

11. The method of Claim 4 wherein (c) comprises summing or subtracting a first voltage and a second voltage.

12. The method of Claim 4 wherein (c) comprises summing a zero value first voltage with the second voltage.

13. The method of Claim 4 wherein (c) comprises generating the transmit waveform with at least eight different non-zero voltage levels.

14. The method of Claim 2 wherein (c) comprises applying the transmit waveform to an ultrasound transducer element where the transmit waveform is responsive to a sum function of the first and second voltages.

15. The method of Claim 14 wherein (a) comprises:

(a1) providing a first primary winding of the first transformer, the first primary winding tapped by at least a voltage source and three switches; and

(a2) connecting one of the three switches to ground.

16. The method of Claim 14 wherein (c) comprises generating the transmit waveform having at least four voltage levels, the at least four voltage levels responsive to first and second winding ratios of the first and second transformers, respectively, the first winding ratio different than the second winding ratio.

17. The method of Claim 14 further comprising:

(d) tapping first and second primary windings of the first and second transformers, respectively, with a same voltage source.

18. The method of Claim 14 wherein (a) comprises generating the first voltage as a function of time and a maximum number of states of the first transformer; and (b) comprises generating the second voltage as a function of time and a maximum number of states of the second transformer, the maximum number of states of the first transformer different than the maximum number of states of the second transformer.

19. The method of Claim 14 wherein (a) comprises generating a negative voltage and (b) comprises generating a positive voltage.

20. The method of Claim 14 wherein (a) comprises generating the first voltage in response to a superposition of magnetic flux from first and second separate flux paths in a third flux path.

21. The method of Claim 16 further comprising:

(d) controlling the sum function as a function of base four control signals for each of the first and second transformers.

22. An ultrasound transmitter for generating multiple level transmit waveforms, the transmitter comprising:

a transducer element; and

a transformer having a core with at least first, second and third flux paths, a secondary winding around the third flux path, first and second primary windings around the first and second flux paths, respectively, the secondary winding connected with the transducer element and responsive to transmit voltages from the first and second primary windings.

23. The transmitter of Claim 22 wherein the transformer is operable to output a secondary voltage at the secondary winding, the secondary voltage a sum of first and second voltages at the first and second primary windings, respectively.

24. The transmitter of Claim 22 wherein a receive amplifier is connected with the secondary winding.

25. The transmitter of Claim 22 wherein the transformer further comprises fourth and fifth flux paths. ~~(or more?)~~ BP 2/15/02 BP 2/15/02

26. The transmitter of Claim 22 further comprising:
first and second switches connected to opposite ends of the first primary winding; and
a first voltage source connected to the first primary winding.

27. The transmitter of Claim 26 further comprising:
a zero voltage winding around the first flux path; and
third and fourth switches connected with opposite ends of the zero voltage winding, respectively, and ground.

28. The transmitter of Claim 27 wherein the zero voltage winding is untapped and the third and fourth switches are operable to connect the zero voltage winding to ground when the first and second switches are open.

29. The transmitter of Claim 26 further comprising:
third and fourth switches connected to opposite ends of the second primary winding; and
a second voltage source connected to the second primary winding.

30. The transmitter of Claim 29 wherein the first voltage source is operable to output a different voltage than the second voltage source.

31. The transmitter of Claim 29 wherein second primary winding is operable to output a negative voltage and the first primary winding is operable to output a positive voltage.

32. An ultrasound transmitter for generating multiple level transmit waveforms, the transmitter comprising:

an ultrasound transducer element;

first and second transformers having first and second secondary windings, respectively, connected in series, the transducer element connected in series with the first and second secondary windings, the first and second transformers having first and second primary windings, respectively; and

first and second switches connected with the first and second primary windings;

wherein a transmit pulse at the ultrasound transducer element is responsive to the first and second switches.

33. The transmitter of Claim 32 wherein the transmit pulse comprises an output voltage, the output voltage a sum of voltages on the first and second primary windings.

34. The transmitter of Claim 32 further comprising:

third and fourth switches connectable between the first primary winding and ground;

wherein the first switch is connectable between the first primary winding and ground on a different side of a voltage source tap of the first primary winding than the third switch.

35. The transmitter of Claim 32 wherein a first turns ratio of the first primary winding to the first secondary winding is different than a second turns ratio of the second primary winding to the second secondary winding.

36. The transmitter of Claim 35 wherein a same voltage source taps the first primary winding and the second primary winding.

37. The transmitter of Claim 35 wherein the transmit pulse has at least four levels, the at least four levels responsive to the different winding ratios.

38. The transmitter of Claim 32 wherein the first secondary winding is operable to output a negative voltage and the second secondary winding is operable to output a positive voltage.

39. The transmitter of Claim 32 wherein the first transformer has at least three separate flux paths, the first primary winding comprising separate windings around first and second of the three separate flux paths and the first secondary winding around a third of the three separate flux paths.